The Structural Dynamics Validation Challenge Problem: An approximation-theoretic approach

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Abstract

The Structural Dynamics Challenge problem is addressed. The model validation question is treated as a statistical test of hypothesis. The sampling distributions on which this test is predicated are accurately defined and characterized through a statistical inverse analysis. This has required the proper delineation of the potential sources of uncertainty and their representation in a computationally tractable manner, as well as the representation of their effects in a quantifiable manner.

A probabilistic framework is thus adopted for the statement of the problem. It is recognized that a formulation that is consistent with the validation task must recognize two essential components: the measure of variability that is consistent with the available data, and the need to accurately estimate the sensitivity of model-based prediction with respect to perturbations in this measure. These two ingredients are mathematically described within the polynomial chaos approach to describing random variables and processes. A maximum likelihood approach is adopted for characterizing the polynomial chaos representation of the eigenvalues and eigenvectors using the experimentally-derived dataset. An asymptotic distribution of the coefficients in these representations is obtained that permits their characterization as random variables. This results in a polynomial chaos expansion the coefficients of which are themselves random variables, statistically independent from the randomness of the polynomial chaos basis. This enables the description of a family of random variables all consistent with available information. Standard approximation techniques over product spaces permit the propagation of the uncertainty to the predictions, while allowing the evaluation of the corresponding sensitivity of the predictions.